PCT/US04/ **Gas-Fired Portable Unvented Infrared Heater**

Cross-Reference to Related Applications

This application is a continuation-in-part of United States Patent Application Serial No. 10/605,486, filed October 2, 2003, which is a continuation-in-part of United States Patent Application Serial No. 10/051,561, filed January 18, 2002, which is a continuation application of United States Patent Application Serial No. 09/731,156, filed on December 6, 2000, now United States Patent No. 6,340,298, which is a non-provisional patent application of United States Patent Application Serial No. 60/169,062, filed December 6, 1999.

Technical Field

This invention relates generally to improved portable heaters used in relatively small enclosures. More particularly, the invention relates to a uniquely configured propane source infrared heater for use in enclosures such as small recreational enclosures, temporary work enclosures, or vehicles. Although the invention was designed for indoor areas, it will be appreciated that it has broader applications and may be advantageously employed in a wide variety of environments without departing from the scope of the invention.

Background of the Invention

Gas-fired portable heaters are well known in the art and are used in multiple environments. The heater typically includes a housing having a chamber. The housing has an inlet for receiving air into the chamber. Gas is introduced into the chamber to be mixed with the air in order to complete combustion and provide an infrared heating surface. A plenum directs the heat toward a mesh screen and evenly distributes it over the surface thereof. The overall goal in designing such a unit is to achieve a radiant surface that provides even, stable heating over the entire surface.

The use of such heaters is strictly regulated for outdoor only use due to the emission of carbon monoxide. Prior designs in existing portable units are subject to a wide variety of problems. Most importantly, the prior designs are not safe or certified to operate in small recreational enclosures such as tents, truck-caps, fishing huts, trailers, vans, etc. There are a few reasons why the devices found in the prior art are not adequate to perform in such environments. First, the portable heaters that exist today operate at a high pressure generally on the order of 12 psi. Specifically, the pressure from the propane tank through a regulator is necessarily high in order to achieve adequate gas and air flow. In addition to requiring high pressure, previous designs do not have the ability to pass strict combustion requirements at a high and low firing

condition and at a reduced pressure. For example, a new standard developed for this product (CSA International 4.98 US) states that "the appliance shall not produce carbon monoxide in excess of 0.010 (100 ppm) percent in a room with no air changes occurring during combustion of the amount of gas necessary to reduce the oxygen content of the room to 18 percent by volume." In addition, they do not possess an oxygen depletion system ("ODS") (Capreci/Part No. 21500). These shortcomings have prevented the portable heaters found in the prior art from adequately performing in small recreational and temporary work enclosures.

Therefore, a need exists to provide a portable infrared heater capable of performing safely in small recreational enclosures and temporary work enclosures.

Summary of the Invention

This invention contemplates a new and improved burner assembly that is capable of performing safely in small recreational facilities such as tents, truck-caps, vans, fishing huts, trailers, etc.

According to the present invention, a portable heater includes an outer housing having a first or front face, a second or rear face, and two sides interconnecting the front and rear faces. An air inlet is located on the front face of the housing, preferably along a lower portion thereof. A gas supply or tank is partially enclosed and supported by the outer housing. A burner venturi, having a cylindrical body extending upwardly at a slight angle, is disposed within the housing. The burner venturi also has a mouth operatively associated with a bottom end of the cylindrical body. Gas is released from the gas supply into the mouth of the burner venturi. At the same time, air is drawn into the mouth of the burner venturi from the air inlet. The air and gas mix thoroughly as they travel upwardly through the burner venturi.

Upon exiting the burner venturi, a baffle directs the air/gas mixture into a plenum to further mix, enter a rear face of a radiant surface, and then ignited on a top surface where combustion occurs. Any conventional means for initially sparking or igniting the air/gas mixture at the burner surface can be used. The burner plenum is heated to an elevated temperature and the radiant surface emits heat to the ambient environment. Combustion products are directed off a deflector shield which reduces the temperature of the products before exiting an outlet at an upper portion of the housing.

The air inlet of the present invention is advantageously designed to provide air flow along the hot burner plenum resulting in an increased velocity of air flow to the burner venturi. As the burner venturi is heated, the thermal properties result in the air/gas mixture passing upwardly through the angled burner venturi creating a chimney

type effect. The chimney effect created by the present invention increases the air flow velocity into the burner venturi. In addition, the device reduces pressure from the gas supply and has the ability to satisfy combustion requirements at low fire condition.

These and other objects of the present invention will become more readily apparent from a reading of the following detailed description taken in conjunction with the accompanying drawings wherein like reference numerals indicate similar parts, and with further reference to the appended claims.

Brief Description of the Drawings

The invention may take physical form in certain parts and arrangements of parts, a preferred embodiment of which will be described in detail in the specification and illustrated in the accompanying drawings which form a part hereof, and wherein:

FIG. 1 is a perspective cross-sectional view of a heater assembly in accordance with the teachings of the present invention;

FIG. 2 is a longitudinal cross-sectional view of the heater assembly in accordance with the present invention;

FIG. 3 is an enlarged elevational view of a thermocouple, spark igniter, and pilot tube assembly used in the preferred embodiment of the present invention;

FIG. 4 is a perspective view of the heater taken generally from the front and left-hand side;

FIG. 5 is a perspective view of the heater taken generally from the front and right-hand side;

FIG. 6 is a perspective view of the heater taken generally from the rear and right-hand side;

FIG. 7 is a perspective view of the heater taken generally from the rear and left-hand side;

FIG. 8 is a perspective elevational view of the heater in accordance with the present invention;

FIG. 9 is a bottom view of the portable heater;

FIG. 10 is a side elevational view of the portable heater;

FIG. 11 is a side elevational view of the portable heater;

FIG. 12 is a rear elevational view of the portable heater;

FIG. 13 is a front elevational view of the portable heater;

FIG. 14 is a top view of the portable heater;

FIG. 15 is a side elevational view of the portable heater showing a fully enclosed fuel source openable by a hinged door;

PCT *FIG. 16* is front elevational view of the portable heater showing an attached battery pack for use with an optional fan to increase circulation;

FIG. 17 is a top perspective view of the portable heater with top handle removed showing an optional rear fan in the housing operated by removable and optionally rechargeable dry cell batteries;

FIG. 18 is a rear elevational view of the portable heater showing a detachable door for enclosing the fuel source;

FIG. 19 is a rear elevational view of the portable heater with the detachable door of *FIG. 18* removed thereby illustrating the fuel source which is pivotable about a fuel supply connection;

FIG. 20 is a top elevational view of the portable heater with handle and front grill removed showing two fuel sources positioned about one side of the heater;

FIG. 21 is a front elevational view of the portable heater of *FIG. 20* showing front fuel source in ghost lines;

FIG. 22 is a top elevational view of an alternative embodiment of the invention illustrating two fuel sources positioned about opposed sides of the heater;

FIG. 23 is a front elevational view of *FIG. 22* illustrating the fuel sources enclosed within a slotted enclosure;

FIG. 24 is a top elevational view of an alternative embodiment of the invention with handle and front grill removed illustrating two fuel sources positioned at the rear of the heater and partially protruding through the rear wall of the heater;

FIG. 25 is a front elevational view of *FIG. 24*;

FIG. 26 is a rear perspective view with rear and side panels removed illustrating pivotable fuel source rotation and battery-powered fan;

FIG. 27 is a bottom perspective view illustrating the optional remote LP gas supply house in a coiled configuration;

FIG. 28 is a side perspective view of an alternative embodiment for the attachment of two fuel regulators illustrating a sliding track arrangement for the fuel regulator connection in conjunction with a flexible braided hose, the heater housing having the enclosing shroud or enclosure removed;

FIG. 29 is a side perspective view of an alternative embodiment of a portion of the portable heater illustrating a fixed fuel regular positioned within the pivotable door of the housing in conjunction with a flexible braided hose;

FIG. 30 is a side perspective view of an alternative embodiment of the attachment for the fuel regulator illustrating a movable fuel regulator attached by a

flexible house with a clip arrangement within the housing for cylinder positioning and retention;

FIG. 31 is a side perspective view of an alternative embodiment of the fuel regulator affixed in the heater housing illustrating a hinged pivotable bracket within which is fixedly positioned a fuel regulator in conjunction with a flexible braided hose;

FIG. 32 is a side perspective view of an alternative embodiment of the fuel regulator illustrating a pivotable weighted clip; and

FIG. 32a is an enlarged side perspective view of the rotating clip of *FIG. 32*; and

FIG. 33 is an enlarged cross-sectional view of a pivotable regulator.

Detailed Description of the Invention

Referring now to the drawings wherein the showings are for purposes of illustrating the preferred embodiment of the invention only and not for purposes of limiting the same, the Figures show a portable heater for use in confined spaces with various configurations for the positioning of the fuel source(s).

Referring now to the drawings wherein the showings are for purposes of illustrating the preferred embodiment of the invention only, and not for purposes of limiting same, the FIGURES show a portable heating device **A** adapted for use in small enclosed environments. Although the present invention is designed for use in recreational enclosures and temporary work enclosures, it will be appreciated that other uses are contemplated.

The portable heater **A** includes a housing **10** having a front face **12**, a rear face **14**, and two sides **16, 18**. The housing **10** is preferably manufactured to have smooth contours to prevent snagging or catching of things such as clothing, fabric, etc. A stepped recess or external cavity is formed in an upper front corner region of the left side **16** of the housing **10** for supporting a control knob or temperature controller **20**. The recess provides protection against inadvertent contact and accidental changing of the temperature. The temperature controller **20** preferably has four positions: off, pilot, low, and high (not shown) although continuously variable positions for infinitely variable heating is also contemplated within the scope of this invention. Controller may incorporate a piezo spark igniter integral to controller stem rotation.

Another recess is disposed on the upper back corner of the left side **16** of the housing **10**. This recess supports an igniter button **22** for activating the heater **A**. This recess also protects against inadvertent contact with the igniter button **22**.

The heater **A** is supported by two elongated legs **24a, 24b** laterally disposed along the outboard edges of the rear face **14** and front face **12** respectively. The legs

24a, 24b are preferably grooved providing a friction surface to contact the supporting surface and preferably extend over the entire width of the housing to provide a wide "footprint" and stable support area for the heater. In another embodiment (not shown), additional legs extending front to rear are provided beneath legs **24a, 24b** to increase air flow beneath the heater. A handle **26** is recessed from and extends from the top of the heater at an angle directed away (approximately 15°) from the front face **12**. The offset allows the handle to remain cool for handling by a user while the angled orientation of the handle **26** protects the user's hand from heat exiting the top of the heater while the user transports the heater. The handle **26** is optionally grooved providing an enhanced gripping surface for the user.

A shield or metal grid **30** is attached to the front face **12** of the heater to provide protection to the heater components. In addition, the shield prevents accidental contact with the hot portions of the heater front face **12**. The shield is preferably made from elongated wire metal strips and peripheral pieces are received in openings **32** in the housing to secure the shield to the heater. In addition, only one screw (not shown) need be removed for access to the interior components enabling easy servicing or replacement of selected components of the heater. Two keyhole openings or recesses **34a, 34b** are located on the upper portion of the back face **14** of the heater allowing the user to hang the heater in an elevated position.

An opening or air inlet **40** is disposed on a lower portion of the front face **12** of the heater for receiving and filtering air drawn into the housing. The air inlet **40** is preferably formed from a series of elongated slits **42** equispaced across the housing beneath the shield. However, any opening that adequately provides air inflow is within the scope of the present invention.

An LP ("Liquified Petroleum" or "Liquified Propane") gas supply tank **50** is secured to and partially enclosed by the housing **10** (See *FIGS. 5* and *6*). The LP gas supply **50** is preferably a removable canister or propane tank that can be replaced by a new tank or removed, refilled, and re-installed in the housing. A conical dome **52** protrudes from the side **18** of the housing **10** and partially encloses the gas supply tank **50**. The dome acts as a protective shroud to cover the interconnection of the tank with the housing. For example, a one pound propane cylinder may be connected to the housing to provide approximately six hours of continuous operation on the low setting. Alternatively, the heater can be supplied, for example, by a conventional twenty pound propane tank having an extended length hose assembly so that the tank can be located away from the heated region. For instance, the propane tank can be positioned outside

a tent, cabin, fishing shanty garage, etc. while the heater is located within the structure and the heater provide on the order of one hundred and ten hours of heat with the larger gas supply tank.

The gas supply **50** is connected to a regulator which connects to a valve and orifice **56** (See *FIG. 1*) which is selectively adjustable between open and closed positions, access being provided to the regulator through window opening **58** for remote LP gas supply hose tightening and leak checking (see *FIG. 6*). Optionally the LP gas supply hose **130** with connector fittings **132, 134** is stored underneath the unit within receptacles **136** in combination with side ledges **138** illustrated in *FIG. 27*. It is recognized that the LP couplings may be "quick connects" when the supply pressure is already regulated to about 11" water column. In this embodiment, the quick-coupler hose is integral to the heater and downstream from heater regulator(s) but before the control valve to facilitate connection to a regulated hose supply from an external fuel source such as a 20 pound cylinder. Similarly, the regulated fuel supply (11" water column) could originate from a self-contained system as in a recreational vehicle. The quick-coupler hose connection would incorporate positive fuel shut-off in both male and female connection components to prevent fuel escape when disconnected.

Referring again to *FIGS. 1* and *2*, a burner venturi **60** is enclosed within the housing **10** and operates to mix oxygen and propane for combustion. The burner venturi **60** has a hollow generally cylindrical body **62** and a tapered mouth **64** having a wider diameter than the body **62**. The burner venturi is disposed at an angle a relative to the longitudinal axis of the heater **A**. The mouth **64** of the burner venturi is positioned on approximately the same axial plane as the air inlet **40** and the cylindrical body **62** extends upwardly from the mouth **64**. The orifice **56** which is attached to the gas supply **50** is located directly beneath the mouth **64** of the burner venturi **60**.

Also located within the housing **A** is a generally planar radiant surface **70** disposed at an angle α relative to the longitudinal axis of the heater. A rear face of the radiant surface is in communication with a cavity or plenum chamber **72**. The burner plenum receives the air/gas mixture from the venturi and distributes the mixture over and through the rear face of the radiant surface. Thus, in operation, the orifice **56**, attached to the gas supply, is opened releasing a fuel gas such as propane into the mouth **64** of the burner venturi **60**. Associated with the orifice is a regulator that reduces the delivery pressure of the fuel gas from the tank (rated up to 150 psi) to eleven inches of water column in one stage. Thus, this portable heater operates at a significantly lower pressure than existing commercially available units. The stream of gas exiting the

orifice **56** creates a vacuum effect drawing air from the air inlet **40** into the mouth **64** of the burner venturi. Propane and air are thoroughly mixed in the burner venturi **60** and plenum **72** in order to achieve complete combustion and produce a clean burning infrared heating surface. The mixture of oxygen and propane travels upward through the cylindrical body **62** of the burner venturi **60** until reaching the plenum chamber **72**. To prevent the mixture of propane and oxygen from immediately exiting the plenum chamber **72**, a solid baffle **76** is provided which forces the air/gas mixture downward into communication with the rear face of the radiant surface.

The radiant surface may be a burner tile or a multi-ply screens (not shown) that define a plurality of small openings which permit combustion of the air/gas mixture as it passes therethrough. A means is provided for initially sparking or igniting the mixture at the radiant surface. In the present invention a container **80** houses the pilot **82** and the igniter **84** (see *FIG. 3*) which provides the initial sparking. It will be appreciated that any conventional means for initially sparking or igniting the mixture can be utilized. Combustion of the air/gas mixture is maintained and reaches elevated temperatures of approximately 1200° F. The heater shown in the drawings with one propane cylinder is rated at a minimum 4000 BTUs and a maximum 9000 BTUs at eleven inches water column pressure. Other ratings are also potential alternatives, including up to 20,000 to 25,000 BTU models when more than one propane cylinder and associated burner assemblies are utilized.

A reflector **90** extends outwardly from the top of the burner plenum **72** at an angle directed toward the top portion of the front face **12** of the housing **10**. The natural convective upward path of the combustion products leads the combustion products into contact with the reflector **90**. The reflector **90**, in addition to directing the radiant energy output from the heater toward the front surface of the housing, also acts as a deflector and reduces the temperature of the combustion products exiting the heater which greatly reduces the chance for ignition of a combustible material if it comes into contact with the heater **A**. An outlet **92** is disposed near the top of the housing **10** allowing warm air to mix with combustion products and exit the device after contacting the reflector **90**. In addition, a deflector **95** is disposed on the top of front face **12** which reduces the temperature of the combustion products exiting the heater which greatly reduces the chance for ignition of a combustible material if it comes into contact with the heater **A**.

In addition, there is an outlet or grate **94** disposed rearward of outlet **92** that communicates with the interior of the housing. It provides a continuous flow path for air

(that does not enter the venturi) to flow from the inlet **40** around the rear of the plenum chamber and exit the housing rearward of the deflector. This enhances the chimney effect as described above since a large amount of ambient air is drawn into the housing, a portion used for combustion purposes and the remainder convects upwardly along the rear of the plenum and the deflector to exit via the openings **94**. The air inlet **40** of the present invention is designed to encourage air flow along the back of the hot burner plenum **72**, advantageously resulting in an increased velocity of air flow to the burner venturi, as well as cooling the rear housing **10**. As the burner venturi **60** is heated, the thermal convection properties urge the air/gas mixture through the upwardly angled burner venturi **60** creating a chimney type effect. The chimney effect created by the present invention increases the fresh air flow velocity into the burner venturi, enabling the pressure from the gas supply **50** to be reduced, yet burn efficiently on high or low settings.

In addition to housing the pilot **82** and the igniter **84**, the container **80** preferably houses an oxygen depletion system (See *FIG. 3*). The oxygen depletion system (ODS) provides an automatic shutoff mechanism when decreased oxygen levels and resulting increased carbon monoxide concentrations are detected. For example, the heater of the present design is intended to automatically shut off at 100 PPM of carbon monoxide at 18% oxygen levels (21% free normal air). A thermocouple **86** monitors changes in temperature of the pilot flame which indicates changes in oxygen and carbon monoxide levels. Previous designs found in the prior art use a thermocouple/plunger type safety shut-off arrangement, which is not deemed to be as sophisticated or precise as the ODS of the present invention. The addition of an ODS to portable unvented heaters is an improvement in the art and the first of its kind. A more detailed discussion of the ODS can be found in a variety of resources.

The present invention significantly reduces the pressure from the propane tank in one stage. The pilot burner must operate at 11" water column (W.C.) while the main burner may optionally operate at this same pressure although higher pressures are envisioned. This is the first portable device for indoor use that the applicant is aware of that conforms to this standard. The portable heaters that exist today all operate at high pressures (on the order of 12 psi) and do not incorporate an ODS. In addition, the present device has the ability to pass combustion requirements at a low fire condition.

In another embodiment of the invention illustrated in *FIG. 15*, the fuel source is positioned within housing **10** and is accessible through pivotable hinged door **100** with latch **102**. Conical dome **52** extends partway down vertical side **18** and over at least a

portion of the valve of fuel supply **50**. Pivotal movement of hinged door **100** is accomplished by the user effecting vertical axial counterclockwise rotational movement about a pair of hinges or pivot axis (not shown) at one side of the door.

FIG. 17 illustrates yet another embodiment of the invention in which improved air flow is effected through heater unit **A** by the incorporation of a paddle or cage fan **110** in back panel **14**. In one aspect shown in *FIG. 16*, a rechargeable battery pack **104** is illustrated to be positionable within accommodating slot **116** within side panel **16** of housing **10**. Knob **106** is used to variably define the power setting used with battery pack **104** as well as to be used as an "on/off" switch for controlling the speed of fan **110**. Alternatively, and in another aspect of the invention, at least one, preferably two or more rechargeable dry cell batteries, **108a**, **108b** are employed within side panel **16** of housing **10** as better illustrated in *FIG. 17*. The batteries are positioned to be loaded from the bottom of housing **10** and, the power controlled by a variably positioned knob **106** located toward the front of housing **10** or at an alternative position as is known in the art for controlling variable amounts of power to an electrical device. Depending on the rotational speed of the fan desired, coupled with battery life expectancy, anywhere from one to four "C" or "D" sized batteries are employed, although it is equally envisioned that "AA" batteries may be used in some models where power consumption is envisioned to be minimal or usage infrequent and for short duration. Fan **110** has a plurality of paddles or inwardly extending panels for creating air movement through rotational pivotal movement about axis **114**. The fan is typically a lower voltage fan, e.g., 3.0 volts, powered by a direct current motor. This increased air flow insures maximal cooling capacity on various metal and plastic components in heater **A**. Battery operation is also illustrated in *FIG. 26* where an alternative dry cell location is identified.

FIGS. 18-19 illustrate another embodiment of the invention in which a snap-fit door **100** is removable from side panel **18** thereby permitting pivotal rotational movement from a first position to a second replaceable position of fuel source **50** by swivel fitting **120**. This configuration allows an end-user to rotate the fuel source for easier canister replacement without having to simultaneously lift the unit. This pivotal coupling is additionally illustrated in *FIG. 26* where one fuel source **50** is shown rotated approximately 90°. Pivotal movement is effected by rotatable fuel supply connection **120** feeding common fuel line **115**. Propane cylinders are secured by threading engagement with regulator **119** held in position by sheet metal bracket **117** with pivot axis. *FIG. 33* better illustrates a *Prior Art* swivel gas connector, one commonly found for example, on heating products and in particular, propane gas grills for outdoor use for

about the past ten years. The Figure illustrates a gas regulator **119** pivotable about an axis. Rotation is effected circular movement of cylindrical rod **174** within the apertures of U-shaped channel bracket **172** in conjunction with similar movement of gas exit port **176** sealingly engaged with the regulator at one end and sealingly engaged about its circumference at an opposed end by a pair of sealing O-rings **166**. Gas exit port is held in place through set screws **168** which penetrate into an annular groove positioned about the circumference of the gas exit port. U-shaped channel bracket **164** secures the gas exit port into the frame of the portable heater.

FIGS. 20-27 illustrate yet another embodiment of the invention in which more than one fuel source is positionable within the housing. As illustrated in *FIG. 20*, two fuel sources **50a, 50b** are positioned within side wall **18** and at least partially covered by dome-shaped shoulders, and in one aspect, completely enclosed therein as illustrated in *FIG. 21*. Temperature controller button **20** and igniter button **22** are positioned similarly to that shown previously in *FIG. 4*.

In *FIGS. 22-23*, two fuel sources **50a, 50b** which are at least partially enclosed by dome-shaped side panels **52a, 52b** are positioned on opposed sides **18, 16** of heater housing **10**. In this particular embodiment, the units are connected by a mixing valve (not shown) and the temperature controller button **20** and igniter button **22** operate to control a single burner unit.

In *FIGS. 24-25*, two fuel sources **50a, 50b** are once again shown, the canisters protruding at least partially from the rear **14** of heater housing **10**. As illustrated in this embodiment, each fuel source has its individual temperature controller buttons **20a, 20b** and igniter buttons **22a, 22b** for controlling the temperature of heater **A**.

It is recognized that when dual fuel source applications are discussed, it is recognized that the heat capacity of each burner need not be the same, and it is within the scope of this invention that different capacity burners are envisioned. For maximum heat control by the end-user, it is within the scope of the invention that one burner will be for "low" capacity applications and wherein the second burner will be for "high" capacity applications, and wherein the two burners can be used in combination to produce yet a higher capacity unit. For other applications, there will be two "low" capacity burners employed within one unit as well as applications where there will be two "high" capacity burners employed within the same unit. Optionally, there are applications wherein each burner (if each burner has a separate control) or a combined controller where each burner is commonly controlled) will have an associated "low", "medium" and "high" setting to permit still further refinements in the heat provided by the

device. Additionally, it is envisioned that the heating device will have a single controller and one burner, the controller / burner combination having "low", "medium" and "high" settings. In a more expensive version of the heater, two continuously variable burners will be employed, such variability predicated by the rate at which fuel and/or air is supplied to the burners as well as the capacity of the burners, although it is envisioned that a single continuously variable burner is within the scope of this invention.

It should be noted that in embodiments of this invention in which more than one fuel source is illustrated, that the fuel sources can either be operated in tandem or individually. When operated in tandem, a mixing valve is included prior to the burner. In some embodiments of the invention, the second location of the fuel source is that of a storage capacity only, and the unit operates as previously described. It should also be noted that the handle **26** illustrated in many of the embodiments, is often optional, and that a heater which achieves portability by the incorporation of wheels **120** positioned at the bottom of the unit, better illustrated in *FIG. 25* is within the scope of this invention or wherein the portability is associated with the incorporation of a wheeled dolly-like apparatus. When the wheels are of fairly small size, the number of wheels is at least three, preferably four and they are pivotable about a vertical axis. When the number is three, the wheels are positioned in a triangular fashion with two wheels at opposed ends on one side, and a third wheel in the middle of the unit on an opposed side. When the number is four, the wheels are positioned at the vertices of the base of the unit. In a specialized configuration, the number of wheels can be reduced to two. When used in this manner, the wheels are more similar to rollers and occupy at least 50% of the width of the base, preferably more and extending essentially across a complete side, on both sides of the unit.

Alternative embodiments of the modes of attachment of the regulator are illustrated in *FIGS. 28-32*. *FIG. 28* illustrates an alternative embodiment of the swivel gas connector illustrated in *FIGS. 26-27* and *33* and shows slide channels **140, 142** which contain sliding regulator brackets **152** into which are positioned gas regulators **119**. Flexible gas hose **148** and associated regulator fitting **146** and gas line fitting **150** to secure interconnection between the fuel supply (not shown) and the burner assembly. A convenient pull-tab **144** is optionally incorporated into each regulator bracket **152**.

Fig. 29 illustrates yet another alternative embodiment to the swivel gas connector in which pressure regulator **119** swings out through its fixed positioning within bracket **154** affixed to hinged **158** door assembly **100** by bracket channel **156**. In a manner similar to that described previously with *FIG. 28*, flexible gas hose **148** is used to

interconnect between regulator fitting **146** (not shown) and gas line fitting **150** to secure interconnection between the fuel supply (not shown) and the burner assembly.

FIG. 30 illustrates yet a further alternative embodiment for the positioning of the gas regulator and illustrates an arrangement wherein fuel source **50** with regulator **119** affixed thereto is positionable within the housing by an inwardly-biased resilient spring clip **160** for fastening engagement about a middle of the fuel source and a second U-shaped bracket **162** fixedly attached to the heater housing for positioning about a neck of the fuel source. In a manner similar to that described previously, flexible gas hose **148** is used to interconnect between regulator fitting **146** (not shown) and gas line fitting **150** (not shown) to secure interconnection between fuel supply **50** and the burner assembly.

FIG. 31 illustrates still yet another alternative embodiment for the positioning of the gas regulator and illustrates an arrangement wherein regulator **119** is fixedly secured within arms of inner U-shaped bracket **166** which is pivotable within the arms of outer U-shaped bracket **164** by rotational movement of inner bracket **166** about cylindrical rod **168** through apertures positioned within each of the ends of the arms of the respective U-shaped brackets. Once again in a manner similar to that described previously, flexible gas hose **148** is used to interconnect between regulator fitting **146** (not shown) and gas line fitting **150** (not shown) to secure interconnection between fuel supply **50** (not shown) and the burner assembly.

FIGS. 32 and *32a* illustrate still yet a further alternative embodiment for the positioning of the gas regulator and illustrates an arrangement wherein regulator **119** is additionally equipped with rotating clip **172** with weight **174** positioned about a terminal edge. When the heater is in its up-right position **170** as illustrated in *FIG. 32a*, clip **172** prohibits regulator **119** from rotating. When the heater is positioned on its back side, the clip swings back into a second position **178** due to the gravitational effects upon weight **174** thereby swinging out of the way and allowing pivotal movement of the tank for changing thereof. With the incorporation of a weighted clip, the rotating feature for tank installation and removal is effected without changing the elevation of the tank as it moves from a first angular position to a second angular position.

Therefore, what has been shown and illustrated is a portable heating device in which the fuel source (typically at least one, and preferably two one pound cylinders) plus associated regulator (for decreasing the pressure of the exit port gas) are moveable from a first use position into a second position in which the fuel source is replaced. This mode of operation in one embodiment is effected through the incorporation of a braided

gas hose which employs a sliding mechanism in which the user physically pulls the cylinder from its use position inside the housing, to a replace position outside of the housing via telescoping or sliding movement of rails. In a second embodiment, this mode of operation is effected by the fixed incorporation of the regulator into a door in the housing within which is positioned the fuel source, thereby requiring the user to open the door with cylinder attached for replacement of the cylinder. In a third embodiment, this mode of operation is effected by removal of the fuel source from within the housing which is attached by a clamp and bracket within the housing while in a fourth embodiment, this mode of operation is effected by pivotal movement of a fixed regulator within a pair of U-shaped clamps having a pivot rod interposed therebetween. In yet a fifth embodiment, this mode of operation is effected by a swivel weighted clip which requires tilting of the heater prior to removal of the spent fuel cylinder.

In the foregoing description, certain terms have been used for brevity, clearness and understanding; but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are used for descriptive purposes and are intended to be broadly construed. Moreover, the description and illustration of the invention is by way of example, and the scope of the invention is not limited to the exact details shown or described.

This invention has been described in detail with reference to specific embodiments thereof, including the respective best modes for carrying out each embodiment. It shall be understood that these illustrations are by way of example and not by way of limitation.